the geological history of brachiopods, echinoderms and mollusks. If a suitable environment continues, the specialized organism may continue indefinitely. The idea that genetic variation occurs only in one direction and is irreversible is widespread, but needs substantiation before we accept it into a category of fixed ideas. The world indeed may wait long to see again a four-toed horse, but the reason probably is that we already have a *better* type in the one-toed horse, which replaced the former because it *was* better, not because it was degenerate. If selection, natural or artificial, saw at the present time a distinct advantage in a polydactylous horse, it is quite possible that the type might once again be produced. The animal breeder would ask only such a start as was seen in Cæsar's three-toed steed, to produce a race of polydactyl horses.

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ANOMALOUS RATIOS IN A FAMILY OF YELLOW MICE SUGGESTING LINKAGE BETWEEN THE GENES FOR YELLOW AND FOR BLACK

DURING the course of an experiment involving the breeding of yellow and non-yellow varieties of mice certain anomalous ratios were produced by a family of yellow mice. Since an explanation of these facts brings out considerations regarding yellows which have not been treated in the literature of the subject, it seems well to put the case on record.

The peculiar family originated in a cross of black-and-tan (a very dark form of yellow) with brown. F_1 consisted of blacks and yellows. The blacks when tested proved to be heterozygous for brown and showed in their subsequent generations no peculiarities of inheritance. The F_1 yellows should theoretically have been heterozygous for both black and brown for,

Let YyBB = black-and-tan parent (yellow carrying black) and yybb = brown parent;

Then F_1 should consist of yellows, YybB, and blacks, yyBb.

These F_1 yellows were back-crossed to pure browns.

The progeny distribution to be expected would be as follows:

The F_1 yellow parent, YybB, would form gametes, YB, Yb, yB and yb.

The brown parent, yybb, would form only one type of gamete, *viz.*, yb. The expected zygotic combinations would be

The yellow young obtained from this back-cross should be of two genotypes, YyBb (carrying both black and brown) and

(1)

	YyBb, Yybb	yyBb	yybb
Somatic ratio	2 yellows	1 black	1 brown
Percentage expected	50	25	25
Percentage observed	53.6	28.6	17.7
Number observed	88	47	29

Yybb (carrying brown only). Two were selected for breeding to determine in which genetic class each belonged. If both mice were YyBb we should expect

(2)	2 YyBB	1 yyBB	1 yybb
	2 Yybb		
	4 YybB	2 yyBb	
	8 yellow	3 black	1 brown

If both mice were Yybb, we should expect

(3)	2 Yybb	1 yybb
	2 yellow	1 brown

If one mouse were YyBb and the other Yybb, we should expect

(4)	2 YyBb	1 yyBB	1 yybb
	2 Yybb		
	4 yellow	1 black	1 brown

The actual figures from this mating were (616 × 766) 14 yellow, 4 brown. This result resembles most closely that to be expected if both parents were Yybb. If such were the case, all of the yellows should carry brown only, never black. To test them, two of the 14 yellows were mated with each other (2160 × 2162). They produced 18 yellow, 1 black and 10 brown young. To account for the black young, we must suppose one or both parents (2160 and 2162) to have been heterozygous for black and hence that one of the yellow grandparents (616 or 766) carried black. Black young should have resulted from their mating with each other but failed to do so. Black young were also deficient in the mating of their descendants, 2160 and 2162. The ratio observed among the progeny of 2160 and 2162 indicates that one of them carried black rather than that both of them did, for the expectation if both parents carried black, as in (2), fits even more poorly than the expectation if only one parent carried black, as in (4). The deficiency of black young in the mating of 2162 and 2160 is shown by the percentage of various young observed and expected:

	Yellow	Black	Brown
Per Cent. expected	66.6	16.6	16.6
Per Cent. observed	62.0	3.4	34.5

Of the yellows resulting from this mating six when tested proved to be heterozygous for black as well as brown, while four carried brown only; and of the yellow young resulting from these tests four were shown to carry black and brown, while three carried brown only. Equality of yellows carrying both black and brown and of yellow carrying brown only was expected in contrast with the observed ratio of 10 carrying black and brown to 7 carrying brown only.

CONCLUSIONS

In the case reported the occurrence of black and brown recessives out of crosses between yellows carrying both black and brown is the reverse of that expected because brown (normally recessive to black) has appeared in a frequency more than double the expected, and black has appeared in a frequency less than one third of the expected.

There are three theories which might explain these facts. (1) Reversal of dominance resulting in the dominance of brown over black. This may be discarded because the brown young in this experiment were found not to carry black. (2) Selective fertilization by means of which brown gametes united with brown gametes in more than normal frequency. There is known at present no mechanism for such a type of fertilization nor have any cases of it been shown to occur. (3) Linkage of the genes for yellow and black so that YB and yb gametes are formed more often than yB and Yb gametes. Since in the above matings black animals could only result from a combination of yB with yB or yb the result of a linkage of Y and B would reduce the number of blacks produced. This is substantially the result obtained.

Of the three theories the last is favored because it affords a satisfactory explanation of the observed facts in harmony with other cases of linkage, and because it is more readily susceptible of proof or disproof. It encounters the difficulty of positing a linkage between two genes, one of which (yellow) is either identical with or closely linked to a lethal gene and the other of which has hitherto shown no evidence of being related to the lethal.

It is hoped that more data on the subject will be forthcoming which will show whether the foregoing case is exceptional and due to random sampling or whether the genes for yellow and for black are commonly linked in the gametes of mice.

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